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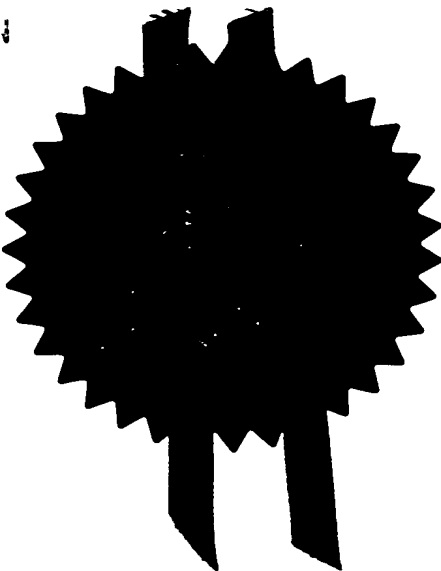
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1. Your reference P22886/CMC/GWO

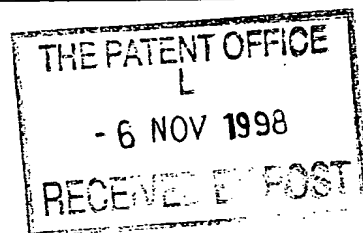
2. Patent application number
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3. Full name, address and postcode of the or of each applicant (underline all surnames)
Kelsill Limited
12 Finch Road
Douglas
Isle of Man
IM1 2SA

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

07 319312001



4. Title of the invention "Electronic Circuit"

5. Name of your agent (if you have one) Murgitroyd & Company

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)
373 Scotland Street
GLASGOW
G5 8QA

Patents ADP number (if you know it) 1198013

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yes

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Continuation sheets of this form -
Description 17
Claim(s) 3
Abstract -
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Priority documents -
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Statement of inventorship and right to grant of a patent (Patents Form 7/77) -
Request for preliminary examination and search (Patents Form 9/77) -
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11. I/We request the grant of a patent on the basis of this application.

Signature 
Murgitroyd & Company

Date 05.11.1998

12. Name and daytime telephone number of person to contact in the United Kingdom

Graham Wotherspoon 0141 429,2200

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1 **ELECTRONIC CIRCUIT**

2

3 This invention relates, in one aspect, to a novel
4 electronic detection circuit and materials for use
5 therewith. The invention relates in other aspects to
6 circuits, materials and techniques relating to security
7 printing.

8

9 The present invention in its broadest sense is
10 concerned with the provision of security in relation to
11 documents, vouchers, packaged goods and tokens of
12 value. Examples of these are banknotes, cheques and
13 drafts, bond and stock certificates, and credit and
14 bank cards. All of these are referred to hereinafter
15 for simplicity as "documents".

16

17 Documents of this nature have the requirement to be as
18 secure as possible against forgery and falsification
19 and for this purpose it is desirable that they exhibit
20 both covert and overt security features. The
21 expression "covert security feature" is used to denote
22 some security feature which is not visually apparent to
23 the normal user, whereas "overt security feature" is
24 used to denote a feature which can be readily seen and
25 recognised by members of the public without the use of
26 specialised equipment or confidential information.
27 Traditional forms of overt security features include

1 water marks, metal security threads, and the use of
2 specialised forms of paper and printing.

3
4 Known methods of covert security include NIR and IR
5 absorber inks, magnetic threads, complex optical and
6 electrically conductive indicia, anti-Stokes, visible-
7 wavelength-emitting phosphors etc.

8
9 With rapid advances in reprographic technology such as
10 relatively cheap and high quality colour photocopiers
11 and easily available digital image manipulation, the
12 traditional forms of security have become increasingly
13 easy to circumvent. There is accordingly a requirement
14 for improved forms of both covert and overt security
15 features, preferably ones which can be used with
16 existing printing technology at modest cost.

17
18 According to one aspect of the present invention, there
19 is provided a method of providing a document with a
20 covert security feature, in which the document is
21 printed using an ink containing a dopant, the dopant
22 being of a material which can be identified by
23 examination of its response to visible wavelength
24 photon radiation.

25
26 This and other aspects and features of the present
27 invention are defined in the appended claims.

28
29 The use of light emitting (inorganic and organic)
30 dopants, either in straight emission mode, Anti-Stokes,
31 IR shifting etc is well known in the prior art, and is
32 commonly practised by using powdered inorganic solids
33 with printing inks. Prior art also exists for doping
34 with unstructured absorbers, such as carbon black.

35
36 What is not known in the prior art is to design

1 inorganic, or organic, dopants with absorption spectra
2 sufficiently different in form and structure from the
3 absorption spectra of printing inks so that the dopants
4 can be easily identified. They thus become very covert
5 because they exhibit no UV, visible or IR stimulated
6 output to be observed by a counterfeiter. The
7 preferred elements for our dopants can be fused with
8 other elements in order to hide the presence of the
9 dopant element, or to alter its absorption spectrum; or
10 the oxide or salt of preferred element itself can be
11 directly mixed into, for example, a printing ink or a
12 batch composition for plastics production etc. When
13 the dopant is mixed with other elemental compounds we
14 have shown that, provided one of its admixture
15 compounds contains a substantial proportion by weight
16 of a light atomic number (z) element, varying the
17 proportion of this compound in the final mix can vary
18 the absorption spectrum of the final inorganic mixture,
19 thus essentially creating further dopants.

20
21 Visible wavelength light authentication of documents in
22 known in the prior art but only in terms of determining
23 the reflection or transmission spectrum of the natural
24 materials of the documents. Such techniques frequently
25 use filters or beam splitters in sets. Such systems
26 suffer from low processing speed, poor optical
27 resolution and hence provide relatively poor security,
28 and are subject to variations in the printed material
29 under examination. Our system depends on the
30 incorporation of a synthesised inorganic dopant into or
31 onto the document at any stage of its manufacture,
32 including the printing stage. These dopants are
33 designed to have very complex visible wavelength
34 absorption spectra, measured in either reflective or
35 transmissive mode. The spectra they exhibit are not
36 found in printing inks or common marbling substrates.

1 This results in high signal-to-noise ratio detection,
2 and hence the ability to identify the dopant in 10msec
3 or less using low output (c. 4W) bulbs as illuminants.
4 The dopants also exhibit complex low (10-60 keV) energy
5 electron excitation spectra which allows sub-surface
6 detection of the dopants which will be described later.
7 The dopant incorporation with its unique spectrographic
8 pattern gives independence from document soiling, wear
9 and tear etc, because it allows excellent signal-to-
10 noise ratio. Pattern recognition software to identify,
11 within 1 msec, the complex signature of our synthesised
12 dopants is readily available from suppliers in the
13 public domain, having been used in optical and nuclear
14 spectrometry for 30 years. Our dopants can be
15 incorporated singly, mixed, or in separate areas to
16 produce a bar code, or to simply confuse a forger. The
17 dopants, depending on composition, are either
18 colourless or transparent, or coloured, at the choice
19 of the user.

20
21 For visible wavelength interpretation the preferred
22 method is to illuminate an area of at least 5mm² by a
23 ring of 6-8 200μ optical fibres in a concentric ring,
24 and channel reflected light through an inner 200μ
25 optical fibre to the wavelength detector. This
26 eliminates the optical losses due to lenses in much
27 prior art, which in turn leads to the processing speed
28 of our system. CCD based wavelength detectors,
29 followed by A-D conversion for processing are standard
30 technologies in public domain electronics. Our dopants
31 are engineered to give no visible signal, such as
32 fluorescence, upon illumination by UV, visible, or IR
33 radiation and are hence not easily replicated as has
34 happened with fluorescent inks, and other emitting
35 technologies.

36

1 Standard printing inks, or colourisers in plastics etc,
2 give relatively unsophisticated reflectance spectra -
3 see for example Figures 1, 2, 3 which show the visible
4 reflectance spectrum of a Pantone standard blue, green
5 and red ink from a paper print. Compare these with
6 Figures 4, 5, 6, 7 which show the visible reflectance
7 spectrum from four of our dopants incorporated in a
8 clear litho varnish and printed on the same paper.
9 These prints are completely colourless to the eye.
10 Figure 4 for example shows many easily identifiable
11 peaks, troughs and turning points in its spectrum with
12 a shape easily distinguished from any ink or colouring
13 dopants. It is these unique features which gives the
14 excellent signal-to-noise ratio, giving the rapid
15 identification ability of our system, with excellent
16 identification rates, and very low false acceptances,
17 together with high rejection for forged copies.

18
19 The features, and/or slopes, of the reflectance spectra
20 can be shifted to create other dopants by incorporating
21 the dopants into inorganic compounds of the type
22 described later.

23
24 The use of visible wavelength spectrometry, as opposed
25 to IR or NIR wavelengths, makes possible many more
26 commercial applications. This is firstly because of
27 the reduced cost of components for the visible, and
28 secondly because the cheapest excitation source is a
29 common (4W) torch bulb which emits plenty of visible
30 light but very little IR. Hence IR and NIR techniques
31 require more powerful and costly excitation sources.
32 Also by moving to the visible we make it easy to
33 construct simple hand-held portable instrumentation
34 which again increases possible commercial applications.

35
36 Visible wavelength spectroscopy as revealed in the

1 prior art with application to security uses lenses or
2 mirrors and lamps to provide the illumination source.

3
4 Many suppliers, such as Oriel Corp. USA, now make
5 commercially available reflectance probes which are
6 about 6mm diameter overall and contain a ring of
7 illuminating fibres (200 μ diameter 5-8 in number)
8 surrounding a centre core of detecting fibres. Use of
9 these probes gives much improved signal-to-noise ratio
10 at the CCD array, or Si photodiode array, or other
11 detector. Using other off-the-shelf components the
12 output of the array spectrometer can be coupled to D-A
13 converters and operated from a laptop, hand-held
14 palmtop, or desktop PC computers. This can easily be
15 interfaced to standard computer software on production
16 lines for authentication at high speed - 10m/sec.

17
18 It is the ready availability of these fibre probes
19 which has made our high speed absorption spectroscopy
20 possible.

21
22 The standard commercial concentric fibre reflectance
23 probes available in the market place have a major
24 drawback in that they require to be placed in contact,
25 or very nearly in contact. For high speed monitoring
26 this gives real problems in object positioning. The
27 optimum would be a fibre probe capable of operating
28 well, yet be 10mm away.

29
30 To achieve this is not simple, because the collected
31 light from the sample has to pass through an entrance
32 slit at the spectrometer, this slit being typically
33 250 μ tall x 100-200 μ wide. The point is this is a
34 rectangle, not a circle, so coupling to fibres
35 efficiently is not simple. The basic probes ignore
36 this.

1 We have arrived at a method of producing the optimal
2 solutions.

3
4 As far as illumination is concerned, the standard
5 stable commercial lamp housings in the range 4-140w of
6 visible light terminate in fibre bundles typically of
7 0.39NA ($NA=1/2f$). The outer concentric ring of fibres
8 is an optimum design needs to match to this NA, so in
9 this example there is only one optimal choice, 400 μ
10 0.39NA fluorinated acrylate clad silica core fibre.

11
12 As far as collection of reflected signal light is
13 concerned standard practice is to consider the optics
14 at the signal end. This is not correct. The whole
15 design of the inner concentric light collecting
16 fibre/fibres in our reflectance probe is dependent on
17 optimising the light collection at the spectrometer.
18 Typically miniature CCD/PDA card spectrometers have
19 focal depth $f=2.27$, so their $NA=0.22$. For true optimal
20 signal light delivery one is then immediately forced to
21 use Si/Si fibre (silica core, silica clad) because its
22 $NA=0.22$, a perfect optimal match.

23
24 By choosing 100 μ $NA=0.22$ Si/Si, we then form bell-end
25 lenses on the signal collection end of each signal
26 collecting fibre. This increases the NA to 0.3 at the
27 ends, giving a 5mm diameter collecting spot for a 1cm
28 stand-off of our optimum probe for reflectance
29 measurements.

30
31 The methodology we have described gives a factor of 10
32 increase in signal delivered to the spectrometer and
33 this is commercially very significant in terms of the
34 performance of equipment in authentication, giving much
35 improved un-ambiguity in decision making.

36

1 Current design of spectrophotometer are all air-spaced:
2 the inputs, mirrors, slits are all separated by air
3 gaps. This leads to light loss inefficiency and
4 sizeable units. Designs are available in the prior art
5 for plastic-spaced spectrometers in which an input
6 fibre is coupled to a thin plastic rectangle with a
7 diffraction grating etched/cut into one end (cf
8 Microports GmbH). These types suffer from the problems
9 of plastic. They only work in the visible, due to the
10 UV and IR absorption in plastic. They have focus
11 problems due to the low refractive index of all
12 plastics compared to glass.

13
14 Our design eliminates these disadvantages by making a
15 solid state spectrometer (about 1"x1"x5mm) out of a
16 machined block of glass. The grating is
17 etched/machined into one end. Variable refractive
18 index glass can be used to ensure total internal
19 reflection at the top faces.

20
21 The edges can be coated black to eliminate serious
22 interfering reflections, or a plastic coating of
23 refractive index lower than the glass can be sprayed on
24 the edges. The higher refractive index of glass, its
25 optical purity, and its composition can easily permit
26 spectrum in the UV, visible and the IR.

27
28 It is more compact because of the higher refractive
29 index of glass, permitting more applications of our
30 dopant technology. The principle is sketched in Fig
31 12, and can be mass produced cheaply. The spectrometer
32 body can be made from a slice of synthetic fused silica
33 allowing use in the UV down to 250nm, as well as in the
34 visible, and out to 2.4 μ in the IR before the first
35 absorption peak in silica occurs.

36

1 The invention also provides a method of providing a
2 document with a covert security feature by use of a
3 dopant which gives a characteristic response to low
4 energy electron irradiation.

5
6 An inspection system for use in the electron probe
7 method comprises a source of low energy electron
8 radiation, said source being positioned to irradiate a
9 document in a predetermined location, a detector
10 positioned to view a document at said location, and
11 processing electronics connected to the detector to
12 assess the presence or absence of a selected dopant or
13 dopants. This electron detection system is sketched in
14 Figs 8 and 9.

15
16 In one suitable form, the radiation source and detector
17 may be mounted in a housing having a common window to
18 which the document may be offered.

19
20 A suitable electron detector is a fast Si-PIN
21 photodiode, as is readily available. A suitable photon
22 detector is a CCD, PIN photodiode or photomultiplier.

23
24 For sub-surface incorporation of our dopants, giving
25 added security, low energy surface-penetrating electron
26 radiation, typically 10-100keV, can be used. The
27 dopants to match this interrogation system are for
28 example based on oxides or salts, of germanium,
29 niobium, strontium, copper, nickel, iron, cobalt,
30 chromium, selenium, lead, zinc, boron, cadmium,
31 manganese, tungsten or vanadium. The electron probe
32 radiation may suitably be provided by conventional low
33 voltage electron guns, or from active source material
34 such as Cd^{109} , Fe^{55} , Am^{241} or Bi^{207} .

35
36 Fig. 8 shows a typical electron probe geometry, Fig 9

1 shows typical circuitry, and Fig 10 shows a typical
2 dopant spectrum from Cd¹⁰⁹ probing of a paper print at
3 30% dopant concentration, by weight, in a 1 μ thick ink
4 film.

5

6 The detector is typically a fast Si-PIN photodiode with
7 a vacuum tight thin window - many types of these are
8 readily available commercially.

9

10 The doped area can be any suitable area of product to
11 be examined. For high speed applications, such an area
12 might well be of the order of 60 mm long x 5 mm wide to
13 allow good data access time by integration when, for
14 example, a banknote passes through detector at high
15 speed, say within a time of 10 millisecond.

16

17 The detection philosophy for sub-surface electron
18 interrogation is that of beta/electron backscatter
19 (where for example a monoenergetic beta source such as
20 Bi²⁰⁷ exhibits clear backscatter peaks from our
21 dopants), or low energy X-ray fluorescence emission
22 from shell electrons of dopants stimulated by a low
23 energy photon source, such as Fe⁵⁵.

24

25 Typical detector circuitry (Figure 9) is shown purely
26 for illustration, and falls for choice into one of two
27 types, either (a) full PHA, pulse height analysis
28 spectral display, or (b) low level single or multiple
29 discriminator windows and a counter, giving rapid
30 identification of dopant presence in a few digital
31 channel peaks, once only a few counts are recorded in
32 each spectral window. These detection methodologies
33 are standard practice in the art, see for example
34 "Radiation Detection and Measurement" by Glenn F Knoll,
35 Wiley & Sons, ISBN 0-471-49545. These detection
36 methodologies are cheap and readily available.

1 The dopants we have identified as working well can be
2 added, as is well known in the art, to standard offset
3 litho printing inks, in quantities up to about 30% by
4 volume without affecting the printing process,
5 providing the dopants we shall describe have been
6 micronised into fine powders of the order of 1-4 μ
7 diameter. If this step is omitted poor uniformity
8 printing results. Our dopants need add no colour to
9 the ink, so give a colourless invisible printed strip
10 onto the object to be protected. Alternatively a
11 colouring dopant can be selected to blend in with an
12 existing coloured scheme.

13
14 A major advantage of our technology is that our dopants
15 are cheap and simple, not requiring the presence of
16 complex expensive chemicals.

17
18 The dopants can be applied to artefacts by any standard
19 deposition technique - air spray, lacquering, printing,
20 stamping.

21
22 The dopants could also be directly incorporated into
23 paper or plastic (for example) at time of manufacture
24 of said paper or plastic. For our techniques to work
25 it is not necessary that the dopants are added as a
26 superior layer or film, although in many cases this
27 will be the simplest and cheapest method. The fact
28 that our dopant/excitation/detector technology does not
29 require surface deposition can offer more
30 security/covertness to the process. It arises because
31 the excitation methods we are employing have ranges of
32 many tens of microns in common materials such as paper
33 and plastics. The fact that our dopant need not be on
34 the surface denies the forger the opportunity to scrape
35 off samples from repeated small surface areas and
36 analyse them to look for "surprising" changes in

1 composition from area to area. Such changes give him a
2 clue that covert technology is being used in that area.

3

4 Purely for illustration of our claim, we list the
5 following suitable dopants which all work well by
6 electron probing in the manner we have described. We
7 know our methodology can be applied by utilising many
8 other dopant species:-

9

10	ZnO	zinc oxide
11	BaSO ₄	barium sulphate
12	BaCO ₃	barium carbonate
13	BaO	barium oxide
14	BiCl ₃	bismuth chloride
15	Bi ₂ O ₃	bismuth oxide
16	CdO	cadmium oxide
17	Gd ₂ O ₃	gadolinium oxide
18	In ₂ O ₃	indium oxide
19	La ₂ O ₃	lanthanum oxide
20	PbCO ₃	lead carbonate
21	PbO	lead monoxide
22	Pb ₂ O ₃	red lead oxide
23	MgO	magnesium oxide
24	MnO	manganese oxide
25	MoO ₃	molybdenum oxide
26	NiO	nickel oxide
27	SrCO ₃	strontium carbonate
28	SrO	strontium oxide
29	Ta ₂ O ₃	tantalum oxide
30	SnO ₂ /SnO	tin oxide
31	TiO ₂	titanium oxide
32	WO ₃	tungsten oxide
33	GeO ₂	geranium oxide
34	V ₂ O ₅	vanadium oxide
35	Na ₂ CO ₃	sodium carbonate
36	K ₂ CO ₃	potassium carbonate

1	Li_2CO_3	lithium carbonate
2	RbCl	rubidium chloride
3	Sc_2O_3	scandium oxide
4	Ta_2O_3	Tantalum oxide
5	TeO_2	tellurium oxide

6
7 The multiple peaks, troughs, and turning points
8 resulting give rapid, positive, unambiguous
9 identification of dopant presence (and hence object
10 authenticity) and allow multiple dopants to be used as
11 a further method of disguise, if required.

12
13 The detector itself is a simple Si-PIN photodiode,
14 typically, available from many suppliers.

15
16 Figure 8 shows one form of detector head which may be
17 used with the circuit of Figure 9, with a source and a
18 detector housed in a common housing and working via a
19 common window.

20
21 Our technique of low voltage electron or visible
22 wavelength photon interrogation of the doped sample
23 means that high detection efficiency (and hence good
24 statistical data output for unambiguous dopant
25 identification) is easily achieved even with small,
26 thin, silicon photodiode detectors.

27
28 Figure 11 shows the efficiency of silicon detectors.
29 The high efficiency at low electron energies is highly
30 relevant to achieving good detection rates, and
31 controls the sources which are usefully employed.

32
33 In the preparation of the inorganic powders for doping
34 to permit identification by visible light wavelengths
35 we arrived at these by not limiting ourselves to
36 chemical compounds which could be formed by

1 precipitation from a solution - because such compounds
2 are limited in numbers. Rather we found the most
3 useful compounds (those with the most distinctive
4 absorption spectra in the visible) could be formed by
5 fusion melting. We found using silicates, phosphates,
6 borates to be the most useful starting points for the
7 fusion, because they give transparent matrices.

8
9 In forming the required solids for powdering, the
10 chemical batch composition is not, for example, limited
11 to that required to produce, say, a glass. This is
12 because long range atomic order is not required in the
13 solid, since homogeneity is assured by the micronising.
14 Indeed in general terms we have found that the best
15 compositions are obtained where phase separation of the
16 melt temperature is imminent. This point is determined
17 experimentally for each composition. Nor need the
18 chemistry be limited to stoichiometric ratios such as to
19 arrive at crystalline compounds, eg as used to produce
20 the commonplace inorganic fluorescence powders added to
21 printing inks.

22
23 In many compositions, the structure and magnitude of
24 the absorption peaks can be controlled over a wide
25 range by control of the gas atmosphere during the melt
26 phase. Again this needs to be established by trial and
27 error for each composition - essentially by test
28 melting each composition in air, in a reducing
29 atmosphere, and in an oxidising atmosphere to determine
30 the optimum methodology for the absorption profile
31 required.

32
33 In many compositions, the structure and magnitude of
34 absorption peaks can be controlled by including a
35 substantial quantity (>20% by weight) of a high Z
36 element in the batch composition (lanthanum, bismuth,

1 and strontium work well, as examples). Then varying
2 the content of this high Z element only gives changes
3 in position and magnitude of the absorption peaks.
4

5 We have shown our dopant technology to work in a wide
6 variety of compounds, including, but not limited to,
7 silicates, borosilicates, borates and germanates. An
8 interesting and suitable composition is of the type 40-
9 56wt% SiO_2 , 5-35wt%, $\text{La}_2\text{O}_3/\text{Bi}_2\text{O}_3/\text{Sr}_2\text{O}_3$, 2-14wt%
10 $\text{Li}_2\text{O}/\text{K}_2\text{O}/\text{Na}_2\text{O}$, 0-6% Al_2O_3 wherein the La, Bi, Sr are
11 examples of a suitable high Z component.
12

13 Another suitable composition is of the type SiO_2 51wt%,
14 B_2O_3 13wt%, Al_2O_3 8wt%, MgO 6wt%, CaO 10wt%, BoO wt%, SrO
15 4wt%, ZnO 4wt%. This is particularly suitable as a base
16 for incorporating dopants for visible wavelength
17 absorption detection because all the base elements have
18 largely unfeatured absorption spectra.
19

20 Incorporation all three alkaline earth, plus BoO , gives
21 much reduced melting temperatures.
22
23

Table 1

1	
2	
3	Preferred element in dopants for electron probing
4	system
5	
6	chromium
7	vanadium
8	iron
9	caesium
10	molybdenum
11	nickel
12	tungsten
13	terbium
14	samarium
15	praesodymium
16	neodymium
17	holmium
18	selenium
19	rhenium
20	thulium
21	ruthenium
22	zinc
23	bismuth
24	lead
25	tin
26	titanium
27	sodium
28	potassium
29	europium
30	

Table 2

1		
2		
3	Preferred elements for dopant fabrication for visible	
4	wavelength absorption system	
5		
6	zinc	
7	barium	
8	lanthanum	samarium
9	lead	praesodymium
10	magnesium	europium
11	strontium	boron-10
12	tin	
13	titanium	neodymium
14	chromium	holmium
15	iron	thulium
16	caesium	cadmium
17	molybdenum	antimony
18	nickel	erbium
19	tungsten	lutecium
20	cobalt	
21	sodium	
22	potassium	
23	terbium	
24		
25		
26		

1 CLAIMS

- 2
- 3 1. A method of providing a document with a covert
4 security feature in which the document is provided
5 with at least one dopant, the dopant being of a
6 material which can be identified by examination of
7 its response to visible wavelength photoz
8 radiation.
9
- 10 2. The method of claim 1, in which the dopant
11 comprises one or more of the elements listed in
12 Table 2, in elemental form or as an oxide or salt.
13
- 14 3. A document provided with a covert security feature
15 by the method of claim 1 or claim 2.
16
- 17 4. A method of examining a document according to
18 claim 3, in which the document is illuminated with
19 broad-band visible light, and the resulting
20 spectrum is compared with a known spectrum.
21
- 22 5. The method of claim 4, in which said comparison is
23 carried out by pattern recognition techniques.
24
- 25 6. The method of claim 4 or claim 5, in which the
26 document is examined using a reflectance probe
27 having a ring of illuminating fibres surrounding a
28 central core of electing fibres.
29
- 30 7. A reflectance probe for use in the method of claim
31 6, in which the illuminating fibres consist of
32 400 μ , 0.39NA fluorinated acrylate clad silica core
33 fibre, preferably between 5 and 8 fibres in
34 number.
35
- 36 8. The probe of claim 7, in which the detecting

1 fibres are 100 μ , 0.22NA silica core, silica clad
2 fibres formed with bell-end lenses to give 0.3NA
3 at the collecting end.
4

5 9. A solid state spectrometer, comprising a machined
6 block of glass having a diffraction grating
7 machined or etched at one end, and having an
8 optical input and a detector located at an
9 opposing face.
10

11 10. The spectrometer of claim 9, in which the glass is
12 fused silica.
13

14 11. The spectrometer of claim 9 or claim 10, in which
15 the detector is a CCD array secured to the face of
16 the glass block.
17

18 12. A method of providing a document with a covert
19 security feature, in which the document is
20 provided with at least one dopant, the dopant
21 being of a material which can be identified by
22 examination of its response to low energy electron
23 radiation.
24

25 13. The method of claim 12 in which the dopant .
26 comprises one or more of the elements listed in
27 Table 1, in elemental form or as oxide, carbonate
28 or sulphate.
29

30 14. A document provided with a covert security feature
31 by the method of claim 12 or claim 13.
32

33 15. A method of examining a document according to
34 claim 14, in which the document is irradiated with
35 low energy electrons.
36

- 1 16. The method of claim 15, in which the electron
2 radiation has an energy between 10keV and 100keV.
3
- 4 17. An inspection system for use with the method of
5 claim 15 or claim 16, comprising a source of low
6 energy electron radiation, said source being
7 positioned to irradiate a document in a
8 predetermined location, a detector positioned to
9 view a document at said location, and processing
10 electronics connected to the detector to asses the
11 presence or absence of a selected dopant or
12 dopants.
13
- 14 18. The inspection system of claims 17, in which the
15 detector is a fast Si-PIN photodiode.
16
- 17 19. The method of any of claims 1, 2, 12 or 13 in
18 which the or each dopant is micronised into a fine
19 powder, preferably 1-4 μ diameter, before being
20 incorporated in a printing ink, lacquer or other
21 suitable carrier.
22
- 23 20. The method of claim 19, in which the or each
24 dopant is formed by fusion melting before
25 micronising.
26
- 27 21. The method of claim 20, in which the fusion
28 melting is of silicates, phosphates or borates.
29
30
31

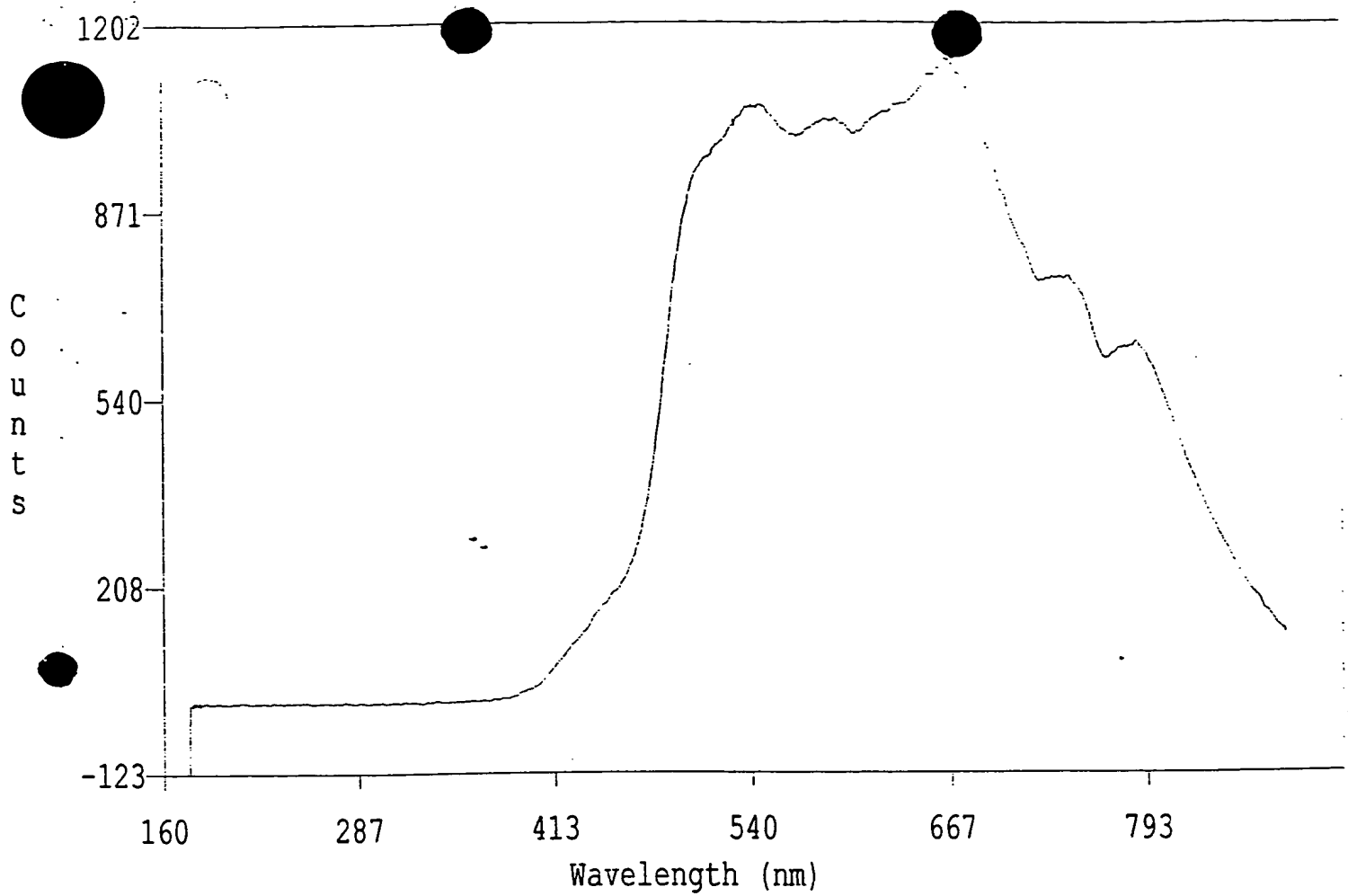


FIG 1 BLUE INK REFLECTANCE SPECTRUM

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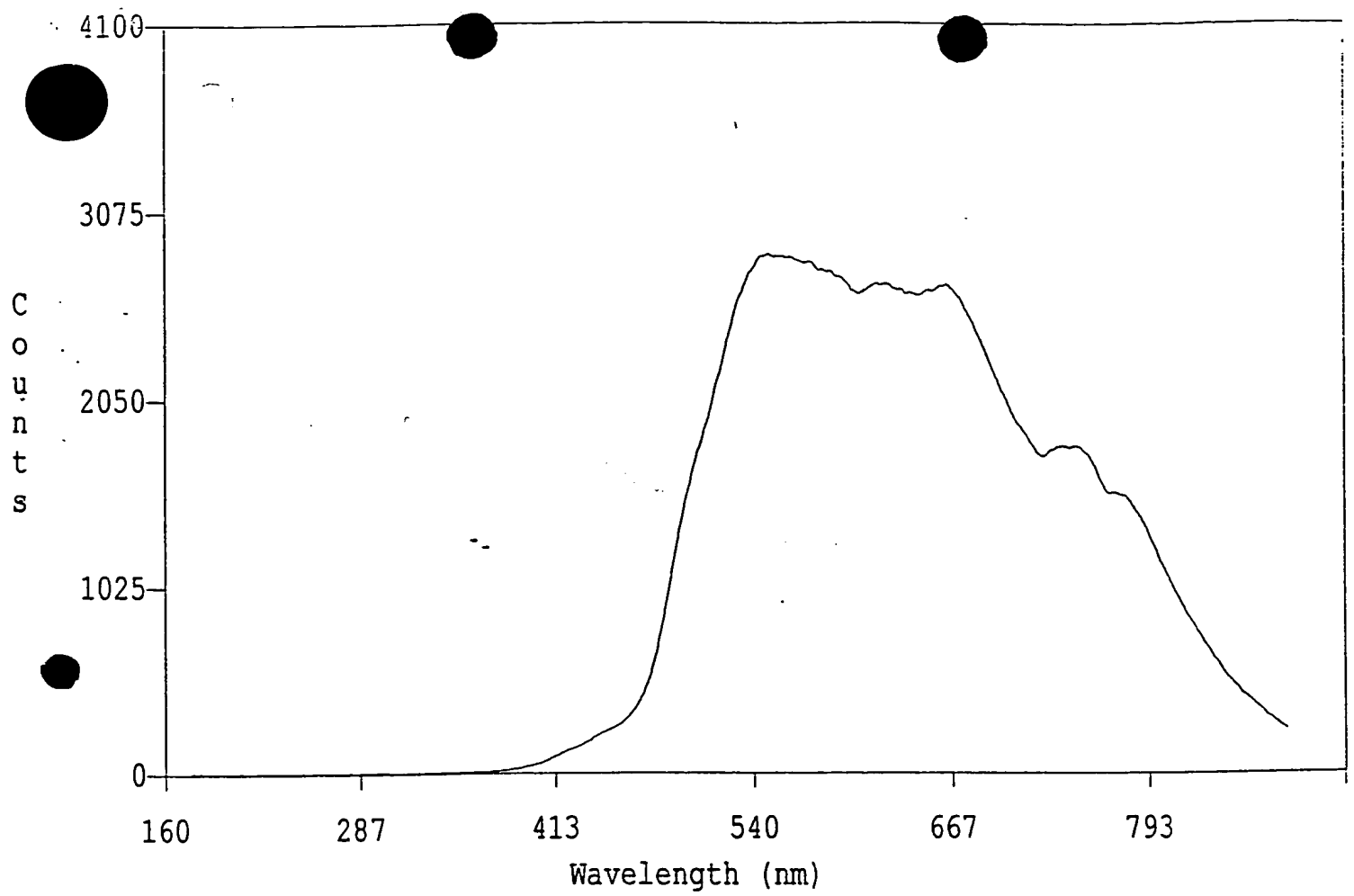


FIG 2 GREEN INK REFLECTANCE SPECTRUM

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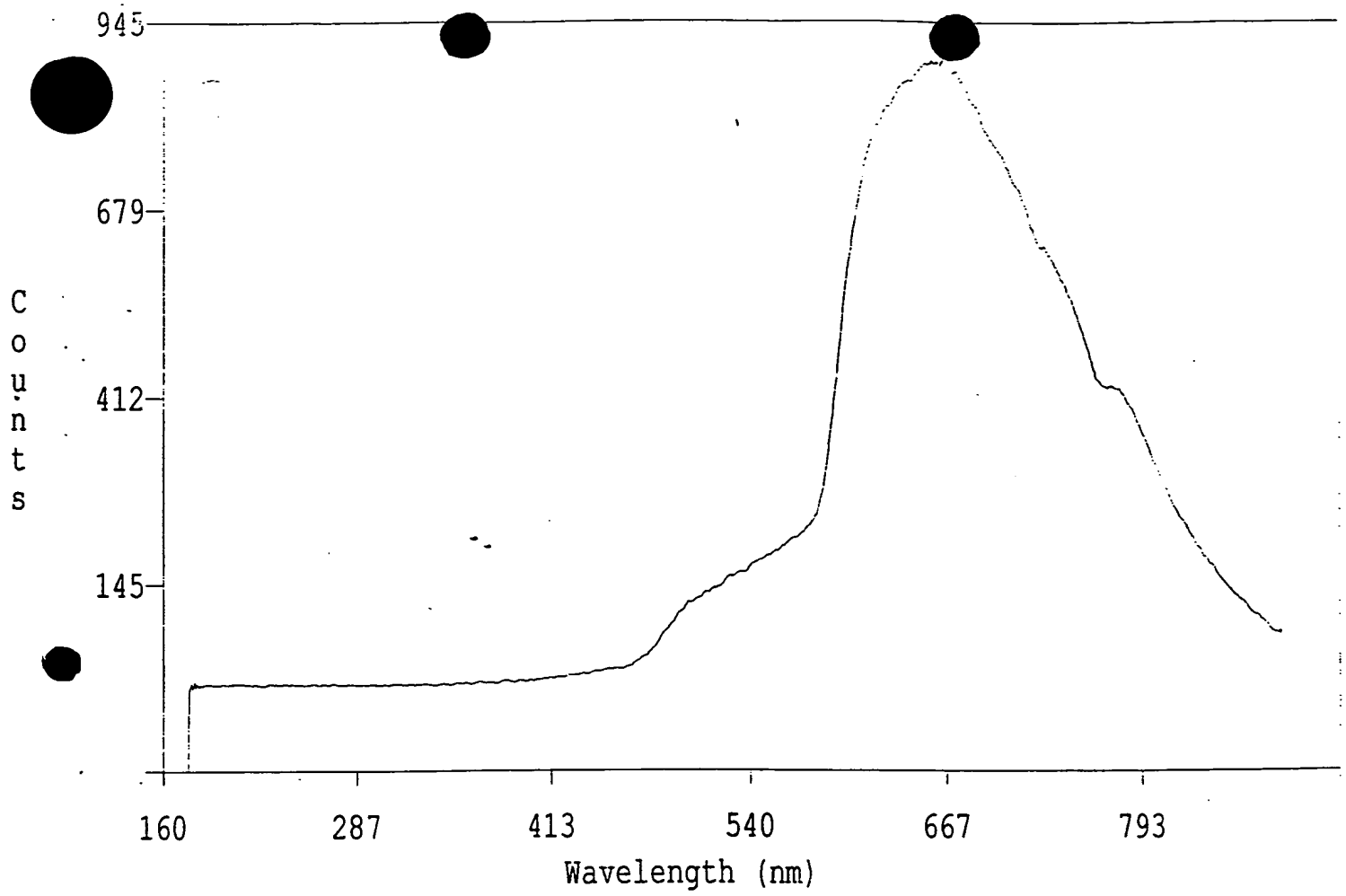
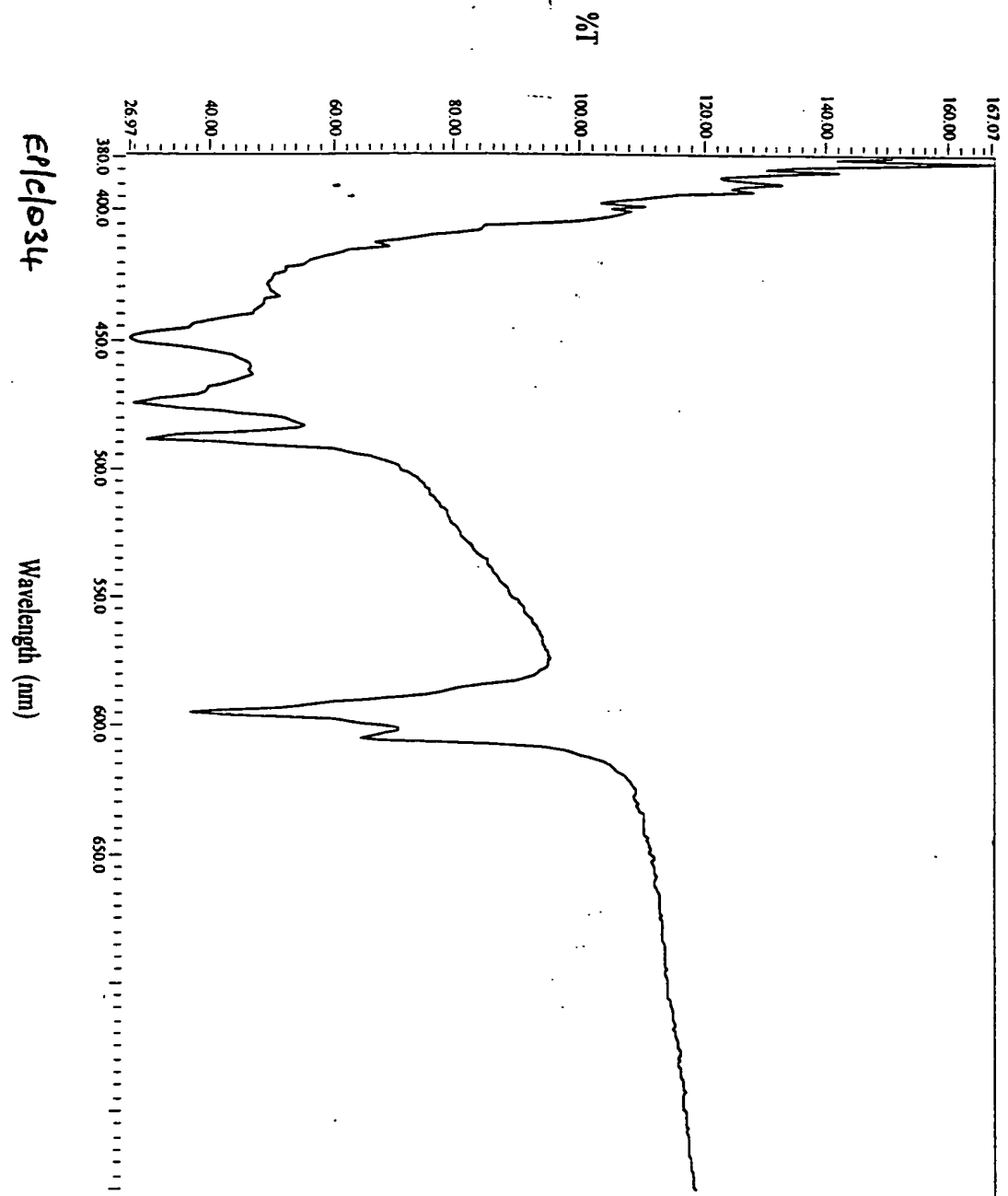


FIG 3: RED INK REFLECTANCE SPECTRUM

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Fig 4

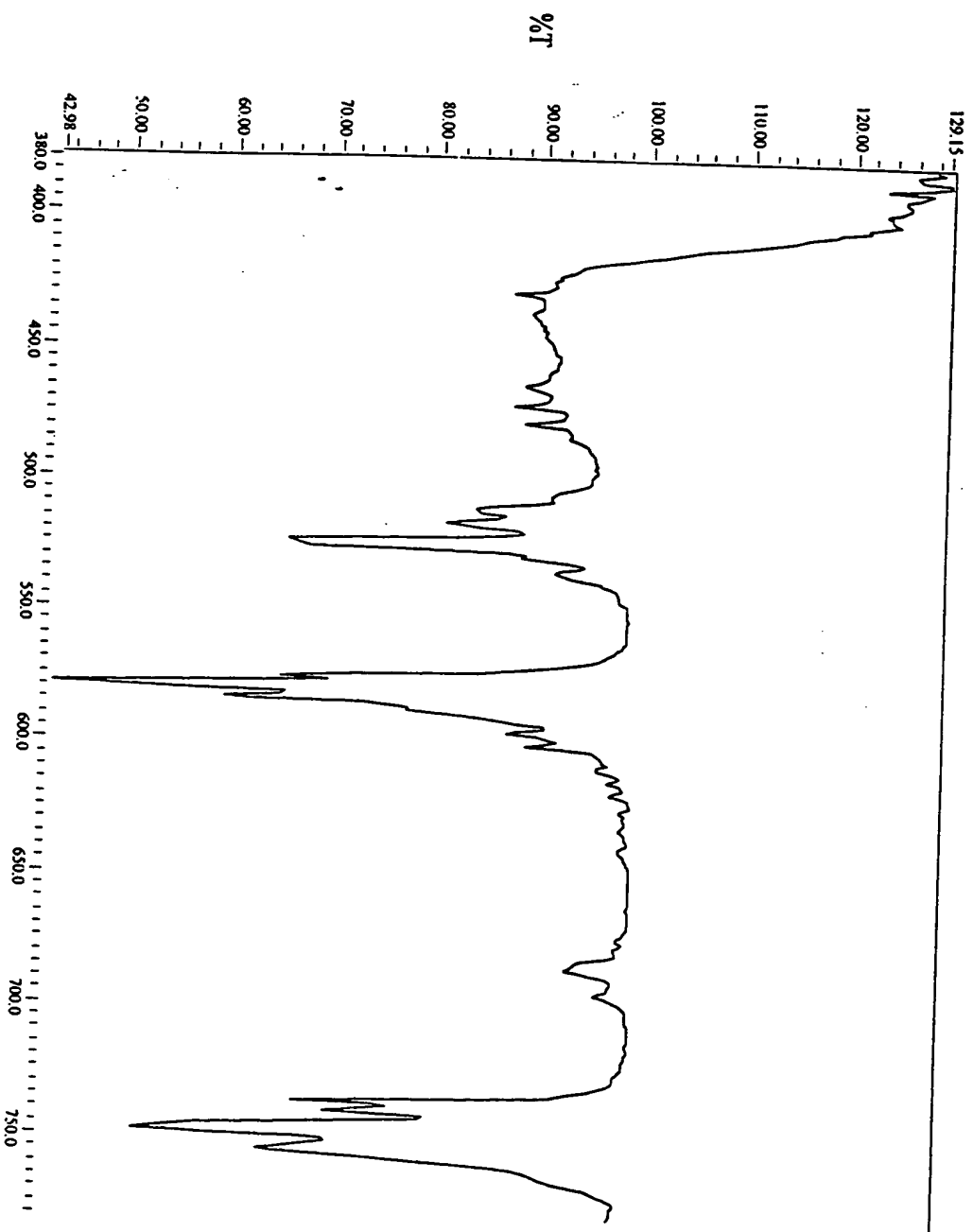


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File 5

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Wavelength (nm)

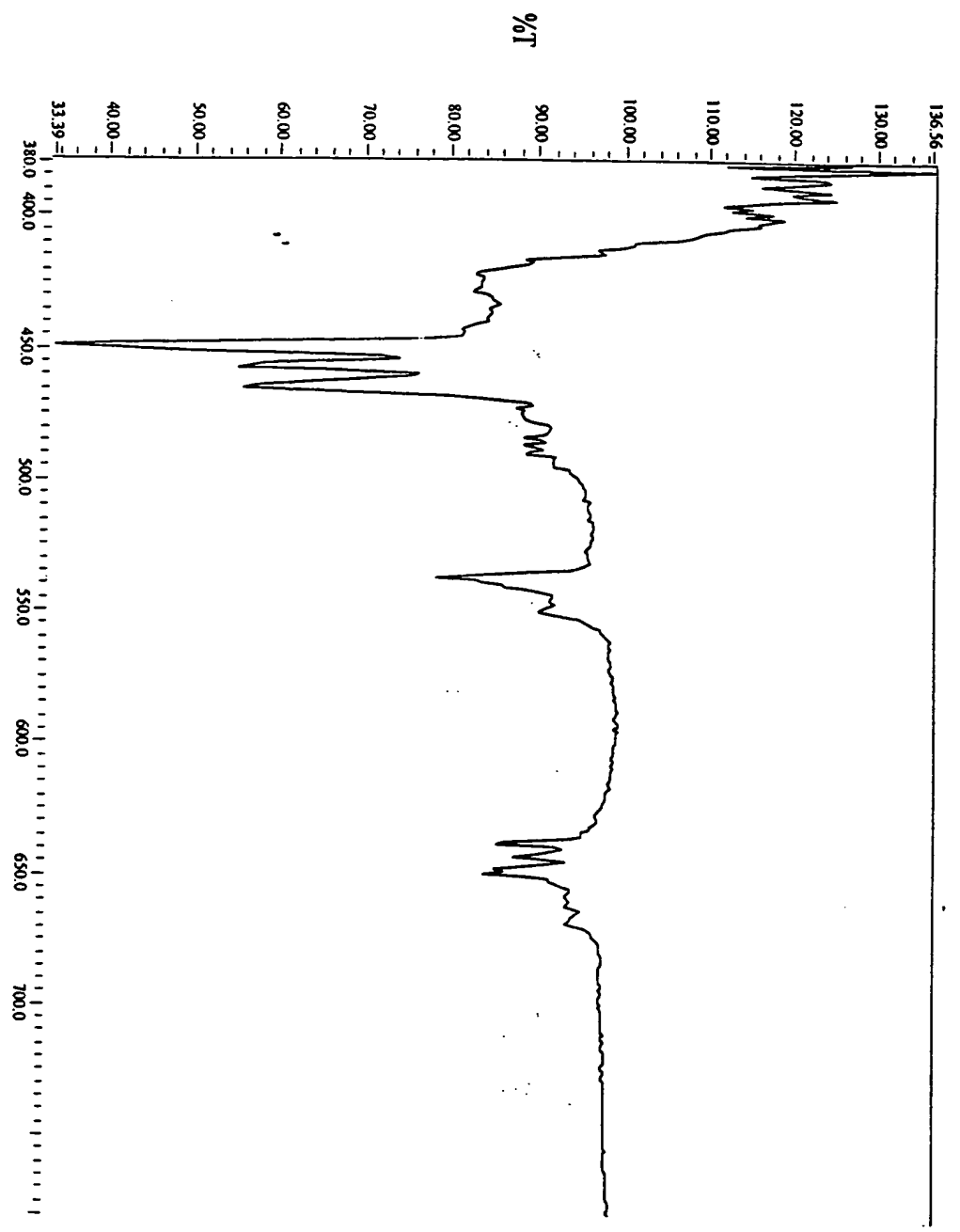


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File 6

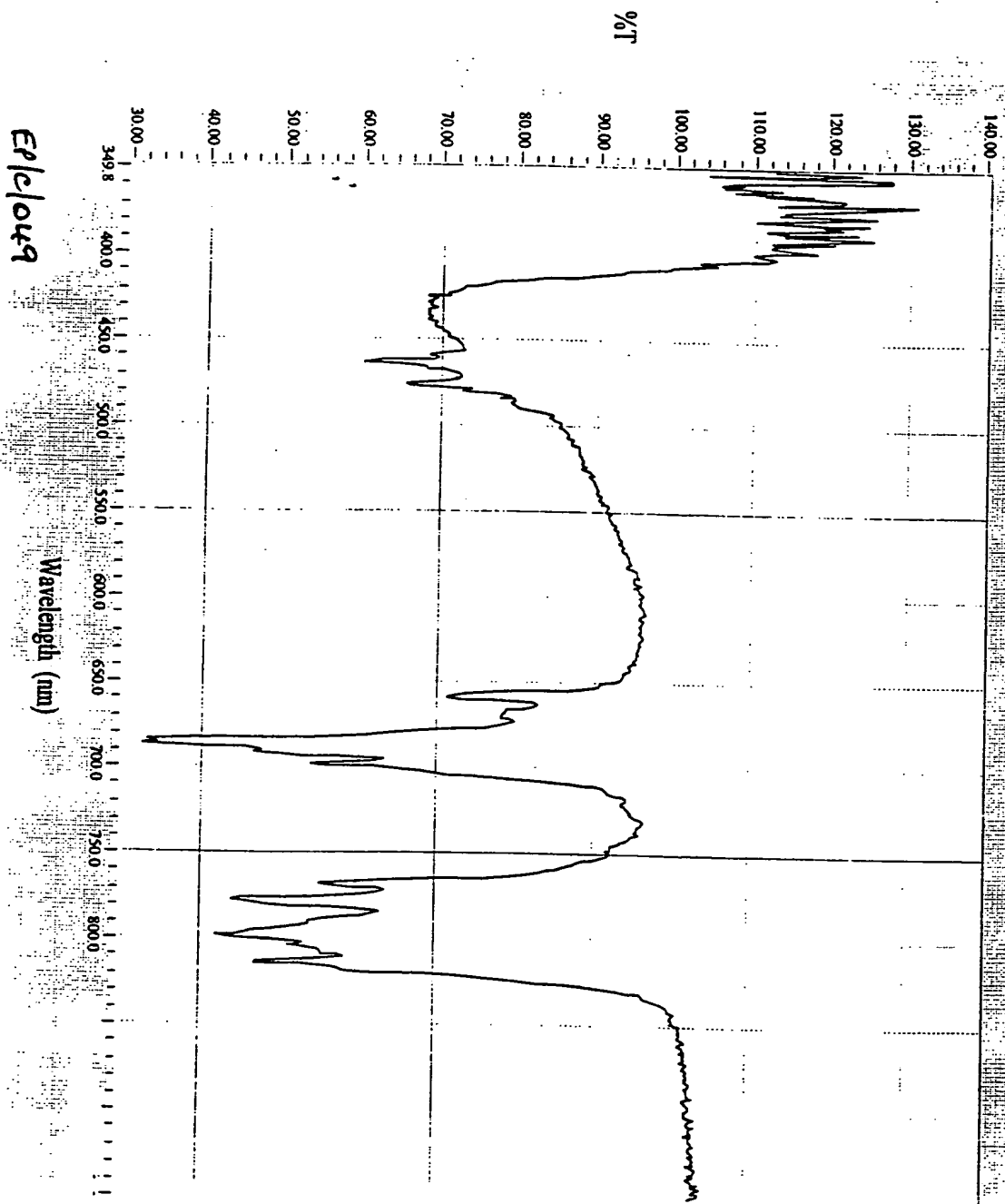
Elc4041

Wavelength (nm)



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Ac 7

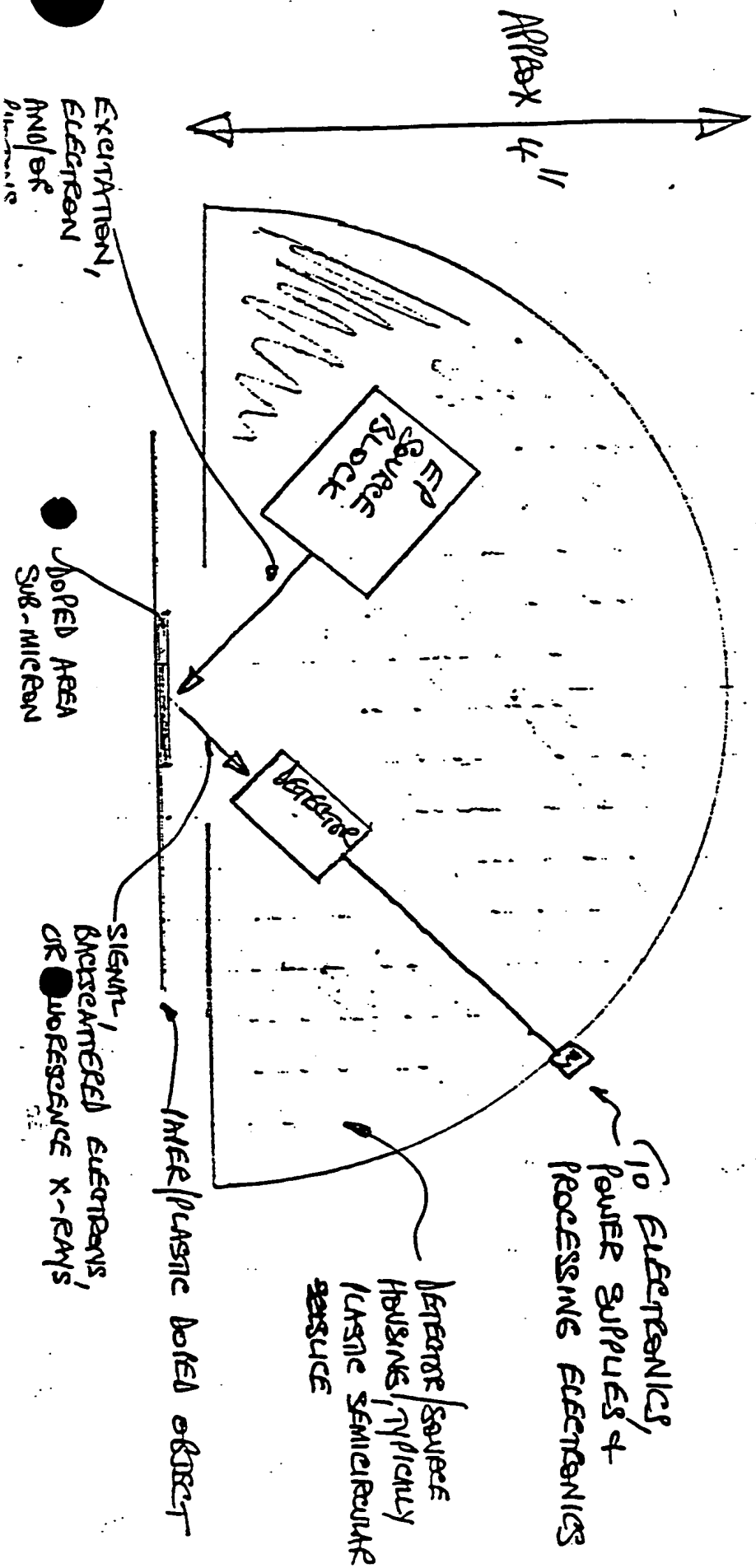


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EP COVER DEFACIT DEFECTIVE HEAD

FIG. 8



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BACK
SCATTERED
ELECTRONS

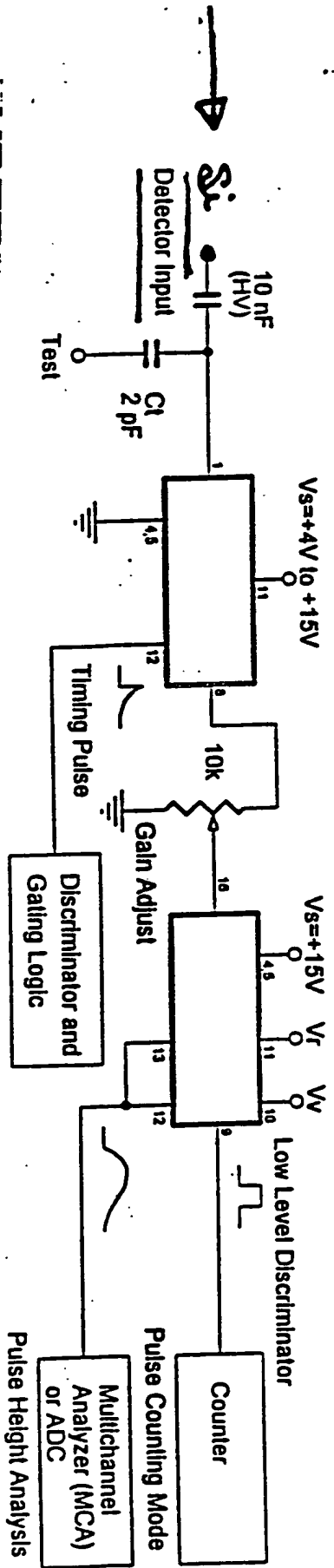
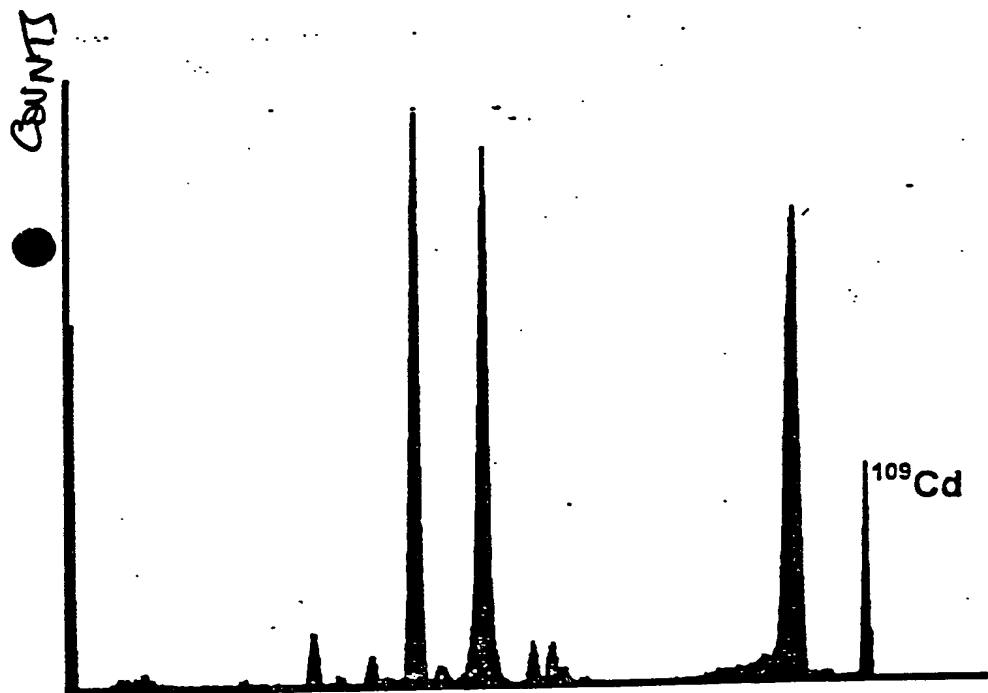


FIG. 9

TYPICAL ELECTRON DETECTOR CIRCUITRY

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ENERGY / VOLTAGE OF OUTPUT PULSES.

FIG. 310

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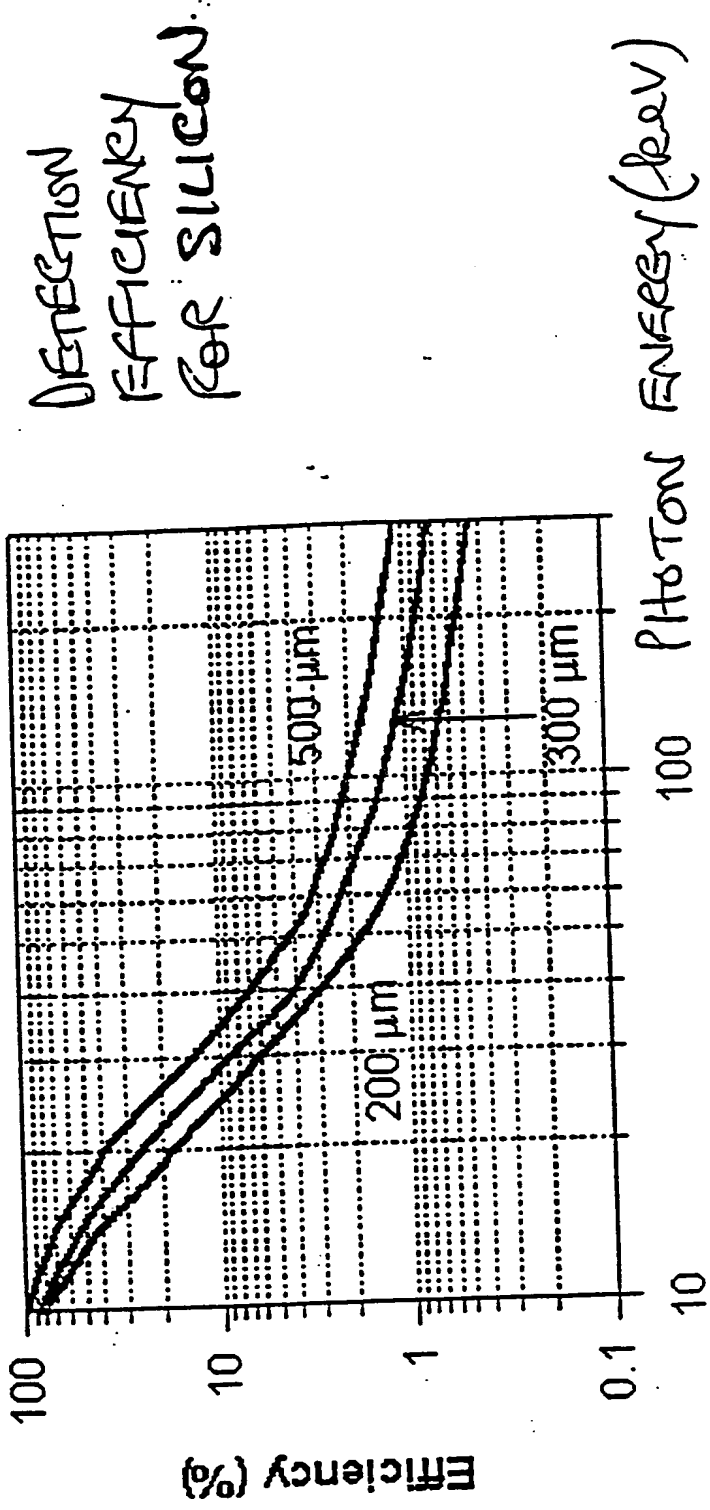
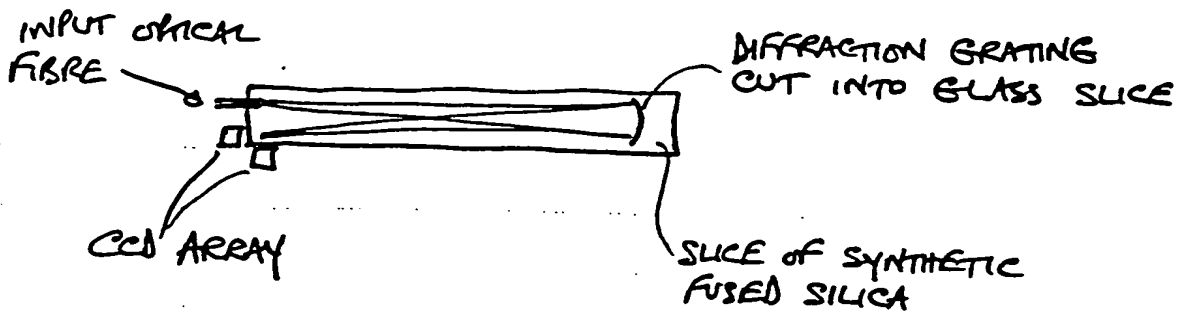


FIG. 11

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SIDE VIEW



TOP VIEW

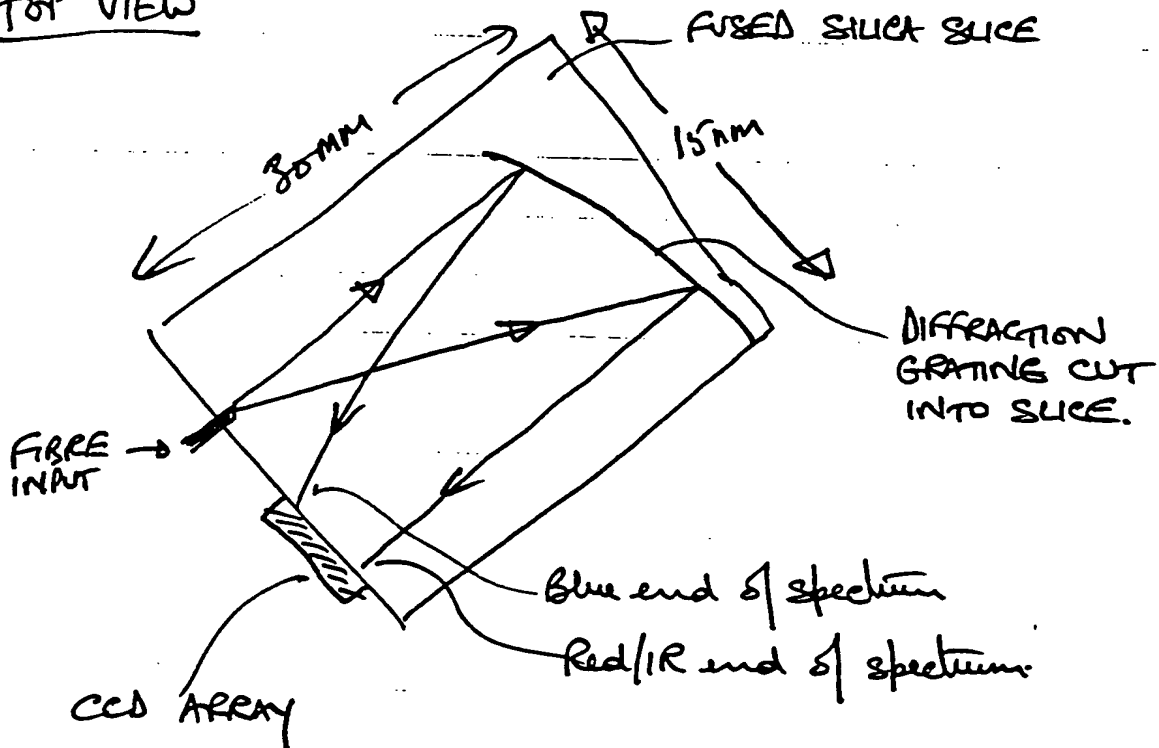


FIG 12 Sketch of principle of glass slice spectrometer.

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